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A COMPATIBILITY EVALUATION OF PLASTIC MEMBRANE FILTERS WITH LIQUID PROPELLANTS AND SOLVENTS

TECHNICAL DOCUMENTARY REPORT NO. RPL-TDR-64-38

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AIR FORCE ROCKET PROPULSION LABORATORY
RESEARCH AND TECHNOLOGY DIVISION
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EDWARDS, CALIFORNIA

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By

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This report has been reviewed and approved.

for J. M. SILK
Colonel, USAF
Director, Air Force Rocket Propulsion Laboratory

ABSTRACT

Data is presented to show the compatibility of polyethylene filter membranes with eleven propellants and eight solvents. More than 300 tests were conducted at ambient temperatures for periods up to 52 hours. The filters tested are satisfactory for use in the gravimetric determination of particulate matter in most liquid propellants.

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A COMPATIBILITY EVALUATION OF PLASTIC MEMBRANE FILTERS WITH LIQUID PROPELLANTS AND SOLVENTS

INTRODUCTION.

Particle contamination and procedures for measuring particulates have long been serious problems in rocket propulsion systems. To better understand and resolve some of the problems in this area, two principal contracts were awarded: Air Products[1] for measuring contaminants in cryogenics, and the Fluor Corporation[2-5] to develop methods for sampling and laboratory analysis. One of the procedures recommended by the contractors involved the use of the cellulose membrane filter. However, the cellulose membrane is not compatible with most storable propellants and often disintegrates when used with cryogenics.

A membrane filter was developed by the Millipore Corporation[6] to replace the cellulose filter. This new filter is relatively inert to all missile propellants, has good retention efficiency, provides surface filtration, has uniform pore size in the 1-10 micron range, and the weight of an individual membrane is less than 100 milligrams.

The purpose of this report is to present the data obtained in the evaluation of the plastic membrane filter with propellants.

TEST PROGRAM.

Description of the Item Tested: The membrane filters tested were polyethylene, 47 mm in diameter, approximately 0.3 mm in thickness, and vary in weight 60-100 mg. Two pore sizes were tested: 1.5 and 10 microns.

Description of Test Apparatus: The test apparatus used in the filter evaluation was composed of standard items:

1. All-glass filter apparatus -- 47 mm pyrex filter holder with tapered ground glass joint between holder base and flask, holding clamp, 300 ml funnel and 1-liter ground joint pyrex flask.

2. Two-inch diameter glass petri dishes.
3. Stainless steel water aspirator.
4. Analytical balance with a minimum sensitivity of 0.05 mg.
5. Vacuum oven.

Propellants Used: All propellants used for testing purposes were taken from storage drums or tanks. The propellants conformed to the requirements listed in the following military specifications:

1. Propellant, Hydrazine - unsDimethylhydrazine (MIL-P-27402).
2. Propellant, Monomethylhydrazine (MIL-P-27404).
3. Propellant, unsDimethylhydrazine (MIL-P-25604A).
4. Propellant, Hydrazine (MIL-P-26536A).
5. Propellant, Hydrogen Peroxide (MIL-P-16005D).
6. Propellant, Nitrogen Tetroxide (MIL-P-26539).
7. Propellant, JP-4/UDMH (MIL-P-26694).
8. Rocket Fuel RP-1 (MIL-P-25576B).
9. Propellant, Nitric Acid (MIL-P-7254 Type III).
10. Propellant, Nitrogen, Pressurizing Agent, Type II (MIL-P-27401B).
11. Propellant, Normal Propyl-Nitrate (MIL-N-8722A).

Solvents Used: A limited number of solvents were used to evaluate the membrane filters. The following solvents were selected on the basis of their compatibility with various propellants:

1. Water
2. Acetone
3. Methylene chloride
4. Petroleum Ether
5. Isopropyl Alcohol
6. Ethyl Alcohol
7. Carbon Tetrachloride
8. Chloroform

Number of Tests: Approximately [illegible] individual tests were conducted on the polyethylene membrane filters. The membranes are categorized as follows: the prototype, the intermediate, and the production item. Over 130 tests were conducted on the prototype membranes, 110 tests on the intermediate, and 90 tests on the production item. The 1.5 micron and 10 micron membranes are grouped together, although they were tested separately. The manufacturing process differed slightly for filters of the two pore sizes, but no distinct difference was noted regarding each membrane's compatibility with the propellants.

Operational Procedure: Prior to each sample test, all items of the filtration apparatus and sample bottle were cleaned with detergent, rinsed twice with distilled water, rinsed twice with isopropyl alcohol, and allowed to dry. Finally, the apparatus was rinsed twice with filtered petroleum ether and allowed to dry until the petroleum ether vapors completely disappeared.

One 10-micron (or 1.5 micron) solvent resistant filter disc was weighed to the nearest 0.1 mg. Forceps were used to place the filter disc in a covered petri dish. An additional filter was weighed and set aside as the control filter.

The control filter disc was removed from the petri dish with forceps and the filter placed on the filter holder base. The tared filter disc was placed directly on top of the control filter. The filter holder funnel was clamped to the base, the vacuum system turned on, and the sample filtered in 200-ml portions. Next, the sample bottle was rinsed with filtered solvent (compatible with the propellant). The sides of the funnel and filter disc were rinsed by pouring the sample bottle rinsings into the funnel. The funnel was disconnected from the base and the filter disc edges rinsed carefully with a jet of filtered solvent to accumulate the particlate residue toward the center of the disc while evacuation continued. The vacuum was released. Forceps were used to place the filter disc in the covered petri dish. The control filter disc was placed in an additional covered petri dish. The dishes, covers ajar, were placed in a vacuum oven at 70°C for 30 minutes. The filter discs were then reweighed at ambient temperature to the nearest 0.1mg.

An additional procedure was used to evaluate the membranes. The tared test membrane and 100 ml of propellant were placed in a closed bottle, mechanically shaken for periods of 15 minutes to 52 hours, and reweighed.

Test Results: The prototype membrane filters were not compatible with most of the propellants. Also, they were unsatisfactory for gravimetric use, i. e., a 100-mg. filter disc lost 10% of its total weight when subjected to red fuming nitric acid (RFNA) for 50 hours in a shaker. These same filters lost 4% of their total weight on direct filtration of 200 ml of RFNA. As the formulation of polyethylene improved, the chemical attack on the membranes by the propellants was less severe.

During the testing of the prototype filters, RFNA and monomethylhydrazine (MMH) were found to be the most incompatible of the propellants used. MMH and RFNA were used almost exclusively to evaluate the intermediate and production item membranes. Typical test results with these two propellants are shown in Table I.

The intermediate filters lost approximately two mg (100 mg disc) with the long-duration RFNA tests, and the production item lost one mg. when subjected to the same test. (A complete list of data is included in the Appendix.)

No membrane completely failed. Swelling occurred with the hydrocarbon fuels, but the membranes showed no loss of elasticity and no distortion with any of the other propellants.

Effect of Solvents: The solvents were more compatible with the production membranes than were the propellants. The results of a 16-hour shaker test are reported in Table II.

The solvent extraction is of little importance, since the initial weight loss is accomplished by the propellant filtration. The tests indicate that the maximum weight loss of membranes occurs in the initial contact with the propellant.

TABLE I

COMPATIBILITY OF MEMBRANES WITH MMH AND RFNA

Control Membrane No.	Initial wt. -mg.	Run #1 Prop. Filtered	Weight Loss mg.	Run #2 Prop. Filtered	Weight Loss mg.	Run #3 Prop. Filtered	Weight Loss mg.
Proto #2	106.7	200 ml. MMH	9.1	200 ml. MMH	1.5	200 ml. MMH	0.3
Proto #10	98.2	200 ml. RFNA	10.4	200 ml. RFNA	0.8	200 ml. RFNA	0.0
Inter. #1	76.5	200 ml. MMH	0.4	200 ml. MMH	0.4	200 ml. MMH	0.1
Inter. #2	77.6	200 ml. RFNA	0.5	200 ml. RFNA	0.1	200 ml. RFNA	0.0
Prod. #1	95.3	500 ml. MMH	0.1	500 ml. MMH	0.0	500 ml. MMH	0.0
Prod. #7	99.3	500 ml. RFNA	0.7	500 ml. RFNA	0.4	500 ml. RFNA	0.0

TABLE II

COMPATIBILITY OF MEMBRANES WITH SOLVENTS

Control Membrane No.	Initial Weight mg	Solvent in Shaker	Weight Loss mg.
Sol. 1	102.1	Methylene Chloride	0.5
Sol. 11	98.0	Petroleum Ether	0.5
Sol. 13	99.7	Acetone	0.3
Sol. 15	101.4	Chloroform	0.9
Sol. 17	100.1	Carbontetrachloride	0.9
Sol. 19	99.1	Isopropyl Alcohol	0.1
Sol. 21	97.5	Ethyl Alcohol	0.1

CONCLUSIONS.

The production membranes, now marketed as Type OS and OH filters, are resistant to most propellants. The membranes are compatible with all of the solvents tested. The membranes may not be used for gravimetric analysis with hydrocarbon-type fuels.

The membrane filters are inexpensive, disposable, easy to use, and have excellent chemical resistance.

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APPENDIX A

COMPATIBILITY OF PROTOTYPE MEMBRANES

COMPATIBILITY OF PROTOTYPE MEMBRANES

Control Membrane No.	Initial Wt. in mgs.	Run #1 Prop. Test	Wt. Loss mg.	Run #2 Prop. Test	Wt. Loss mg.	Run #3 Prop. Test	Wt. Loss mg.	Run #4 Prop. Test	Wt. Loss mg.	Run #5 Prop. Test	Wt. Loss mg.	Percent Total Loss
1	107.0	200 ml. UDMH/ N_2H_4	9.1	200 ml N_2H_4	1.7	200 ml. RFNA	0.3	200 ml. N_2H_4	0.5	200 ml. N_2H_4	0.0	10.8
2	106.7	200 ml. MMH	9.1	200 ml. MMH	1.5	200 ml. MMH	0.3	200 ml. MMH	0.1	200 ml. MMH	0.0	10.3
3	82.6	24-hr Shake N_2H_4	9.4	200 ml. N_2H_4	0.4	200 ml. N_2H_4	0.1	200 ml. N_2H_4	0.0	--	--	12.0
4	90.8	24-hr. Shake UDMH/ N_2H_4	8.3	200 ml. N_2H_4	0.5	200 ml. N_2H_4	0.0	200 ml. N_2H_4	0.0	--	--	9.7
5	99.2	52-hr Shake N_2H_4	11.5	200 ml. N_2H_4	0.0	200 ml JP-X	0.0	200 ml. MMH	0.4	200 ml. MMH	0.0	12.0
6	86.1	52-hr. Shake N_2H_4	7.5	200 ml. N_2H_4	0.0	200 ml. JP-X	0.0	200 ml. MMH	0.3	200 ml. MMH	0.1	9.1
7	91.0	52-hr. Shake N_2H_4	9.0	200 ml. H_2O_2 (90%)	0.0	200 ml. MMH	0.3	200 ml. MMH	0.1	200 ml. MMH	0.0	10.3
8	85.9	52-hr. Shake N_2H_4	7.7	200 ml RFNA	0.0	200 ml. N-Propyl-N	0.0	200 ml. MMH	0.2	200 ml. MMH	0.1	9.2
9	(52-hr 97.4	Shake RFNA	10.2	200 ml. N_2H_4	0.2	200 ml. MMH	0.1	200 ml. MMH	0.0	--	--	10.8

COMPATIBILITY OF PROTOTYPE MEMBRANES (Cont'd)

Control Membrane No.	Initial Wt. in mgs.	Run #1 Prop. Test	Wt. Loss mg.	Run #2 Prop. Test	Wt Loss mg.	Run #3 Prop. Test	Wt Loss mg.	Run #4 Prop. Test	Wt. Loss mg.	Run #5 Prop. Test	Wt. Loss mg.	Percent Total Loss
10	98.2	200 ml. RFNA	10.4	200 ml. RFNA	0.8	200 ml. RFNA	0.0	200 ml. MMH	0.0	—	—	11.4
11	99.6	50-hr Shake RFNA	10.8	18-hr RFNA	0.6	4-hr. RFNA	0.0	200 ml. MMH	0.0	—	—	11.4
12	85.6	42-hr. Shake N_2H_4	7.0	200 ml. N_2H_4	0.5	200 ml MMH	0.0	—	—	—	—	8.8
13	88.4	50-hr. Shake N_2H_4	7.6	18-hr Shake N_2H_4	0.1	4-hr. Shake N_2H_4	0.2	200 ml. MMH	0.0	—	—	8.9
14	85.1	50-hr. Shake N_2H_4	7.0	18-hr. Shake N_2H_4	0.5	4-hr. Shake N_2H_4	0.2	200 ml. MMH	0.0	—	—	9.0
15	80.2	18-hr. Shake N_2H_4	5.3	6-hr. Shake N_2H_4	0.3	18-hr Shake N_2H_4	0.0	200 ml. MMH	0.0	200 ml. RFNA	0.0	7.0
16	79.2	18-hr. Shake UDMH/N_2H_4	4.3	6-hr Shake UDMH/ N_2H_4	0.1	18-hr Shake N_2H_4	0.2	200 ml. MMH	0.0	100 ml. MMH	0.0	5.8
17	86.7	Heat 170°F	0.2	100 ml. H_2O/ Acetone	0.2	200 ml. Conc. HF	9.0	200 ml. MMH	2.0	200 ml. MMH	0.0	6.2
18	78.0	1.5 hr. Shake N_2H_4	4.3	0.5 hr. Shake N_2H_4	0.5	1-hr. Shake N_2H_4	0.1	200 ml. MMH	0.0	—	—	6.3

COMPATIBILITY OF PROTOTYPE MEMBRANES (Cont'd)

Control Membrane No.	Initial Wt. in mgs.	Run #1 Prop. Test	Wt. Loss mg.	Run #2 Prop. Test	Wt. Loss mg.	Run #3 Prop. Test	Wt. Loss mg.	Run #4 Prop. Test	Wt. Loss mg.	Run #5 Prop. Test	Wt. Loss mg.	Percent Total Loss
19	82.7	7.5-hr. Shake RFNA	5.9	0.5-hr. Shake RFNA	0.1	1-hr. Shake RFNA	0.1	200 ml. MMH	0.0	—	—	7.4
20	84.2	200 ml. 90% H_2O_2	3.9	—	—	—	—	—	—	—	—	4.6
21	78.4	200 ml. JP-X	0.7	—	—	—	—	—	—	—	—	0.9
22	98.3	200 ml. MMH	6.9	—	—	—	—	—	—	—	—	7.0
23	83.5	200 ml. MMH	3.5	—	—	—	—	—	—	—	—	4.2
24	78.4	200 ml. MMH	4.5	200 ml. RFNA	0.6	—	—	—	—	—	—	6.0
25	89.6	2000 ml. Liq. N_2	0.1	—	—	—	—	—	—	—	—	0.1
26	82.8	0.1-hr. RFNA	5.0	200 ml. MMH	0.7	200 ml. MMH	0.1	—	—	—	—	7.0
27	73.5	0.2-hr. RFNA	3.0	200 ml. MMH	0.6	200 ml. MMH	0.0	—	—	—	—	4.9
28	92.5	0.5-hr. Shake N_2H_4	8.2	200 ml. MMH	0.5	200 ml. MMH	0.0	—	—	—	—	9.4
29	83.6	0.5-hr. Shake UDMH/N_2H_4	5.9	200 ml. MMH	0.5	200 ml. MMH	0.0	—	—	—	—	7.7
30	98.6	0.5-hr. Shake RFNA	9.0	0.5 hr. Shake RFNA	0.9	200 ml. MMH	0.6	200 ml. MMH	0.0	—	—	10.6

COMPATIBILITY OF PROTOTYPE MEMBRANES (Cont'd)

Control Membrane No.	Initial Wt. in mgs.	Run #1 Prop. Test	Wt. Loss mg	Run #2 Prop. Test	Wt. Loss mg.	Run #3 Prop. Test	Wt. Loss mg	Run #4 Prop. Test	Wt. Loss mg.	Run #5 Prop. Test	Wt. Loss mg.	Percent Total Loss
31	91.5	0.5-hr. Shake RFNA	2.0	0.5-hr. Shake RFNA	1.0	200 ml. MMH	5.2	200 ml. MMH	0.0	—	—	9.0
32	64.4	24-hr. Shake MMH	2.2	48-hr. Shake MMH	0.1	—	—	—	—	—	—	3.6
33	72.9	"	3.8	"	0.1	—	—	—	—	—	—	5.3
34	82.8	"	6.3	"	0.1	—	—	—	—	—	—	7.7
35	95.1	"	10.0	"	0.3	—	—	—	—	—	—	10.8
36	61.9	"	1.9	"	0.2	—	—	—	—	—	—	3.4
37	71.0	"	3.3	"	0.1	—	—	—	—	—	—	4.8

APPENDIX B

COMPATIBILITY OF INTERMEDIATE MEMBRANES

COMPATIBILITY OF INTERMEDIATE MEMBRANES

Control Membrane No.	Initial Wt. in mgs.	Run #1 Prop. Test	Wt. Loss mg.	Run #2 Prop. Test	Wt. Loss mg.	Run #3 Prop. Test	Wt. Loss mg.	Run #4 Prop. Test	Wt. Loss mg.	Run #5 Prop. Test	Wt. Loss mg.	Percent Total Loss
1	76.5	200 ml. MMH	0.4	200 ml. MMH	0.4	200 ml. MMH	0.1	—	—	—	—	1.2
2	77.6	200 ml. RFNA	0.5	200 ml. RFNA	0.1	200 ml. RFNA	0.0	—	—	—	—	0.7
3	79.6	3-hr. Shake N_2H_4	0.7	200 ml. MMH	0.1	200 ml. MMH	0.0	—	—	—	—	1.0
4	78.3	3-hr. Shake RFNA	1.0	200 ml. MMH	0.1	200 ml. MMH	0.0	—	—	—	—	1.4
5	79.8	200 ml. MMH	0.7	—	—	—	—	—	—	—	—	0.9
6	72.0	"	0.6	—	—	—	—	—	—	—	—	0.8
7	76.2	"	0.6	—	—	—	—	—	—	—	—	0.8
8	78.7	200 ml. N_2H_4	0.6	200 ml. N_2H_4	0.3	—	—	—	—	—	—	1.1
9	68.2	"	0.6	"	0.2	—	—	—	—	—	—	1.2
10	71.7	"	0.6	"	0.1	—	—	—	—	—	—	1.0
11	75.0	200 ml. UDMH/N_2H_4	0.6	300 ml. N_2O_4	0.1	200 ml. MMH	0.2	200 ml. MMH	0.0	—	—	1.2
12	79.7	"	0.6	"	0.1	"	0.2	"	0.0	—	—	1.1
13	89.5	200 ml. N_2H_4	0.7	200 ml. N_2H_4	0.1	"	0.5	"	0.6	0.1-hr. Shake MMH	0.3	2.5
14	91.5	"	0.7	"	0.2	"	0.5	"	0.5	"	0.5	2.6
15	90.9	"	0.7	"	0.1	"	0.4	"	0.6	"	0.5	2.5

COMPATIBILITY OF INTERMEDIATE MEMBRANES (Cont'd)

Control Membrane No.	Initial Wt. in mgs.	Run #1 Prop. Test	Wt. Loss mg.	Run #2 Prop. Test	Wt. Loss mg.	Run #3 Prop. Test	Wt. Loss mg.	Run #4 Prop. Test	Wt. Loss mg.	Run #5 Prop. Test	Wt. Loss mg.	Percent Total Loss
16	98.0	3-hr. Shake RFNA	0.8	200 ml. MMH	1.3	200 ml. MMH	0.1	200 ml. MMH	0.0	—	—	2.2
17	87.5	"	1.0	"	0.9	"	0.1	"	0.0	—	—	2.3
18	74.5	20-hr. Shake MMH	1.3	200 ml. MMH	0.0	—	—	—	—	—	—	1.7
19	78.0	"	1.6	"	0.0	—	—	—	—	—	—	2.1
20	68.8	800 ml. MMH	0.5	800 ml. MMH	0.0	—	—	—	—	—	—	0.7
21	67.8	"	0.5	"	0.0	—	—	—	—	—	—	0.8
22	59.9	500 ml. UDMH/N_2H_4	0.3	500 ml. UDMH/N_2H_4	0.3	—	—	—	—	—	—	1.0
23	58.6	"	0.3	"	0.3	—	—	—	—	—	—	1.0
24	61.9	20-hr. Shake MMH	0.6	400 ml. MMH	0.0	—	—	—	—	—	—	1.0
25	61.4	500 ml. MMH	0.5	500 ml. MMH	0.0	—	—	—	—	—	—	0.7
26	62.4	500 ml. UDMH/N_2H_4	0.1	500 ml. UDMH/N_2H_4	0.4	500 ml. UDMH/N_2H_4	0.1	400 ml. MMH	0.0	—	—	1.0
27	102.8	2-hr. Shake MMH	0.3	18-hr. Shake MMH	0.0	—	—	—	—	—	—	0.3
28	101.0	"	0.3	"	0.0	—	—	—	—	—	—	0.3
29	97.4	800 ml. MMH	0.3	800 ml. MMH	0.0	—	—	—	—	—	—	0.3
30	99.4	"	0.4	"	0.0	—	—	—	—	—	—	0.4

COMPATIBILITY OF INTERMEDIATE MEMBRANES (Cont'd)

Control Membrane No.	Initial Wt. in mgs.	Run #1 Prop. Test	Wt. Loss mg.	Run #2 Prop. Test	Wt. Loss mg.	Run #3 Prop. Test	Wt. Loss mg.	Run #4 Prop. Test	Wt. Loss mg	Run #5 Prop. Test	Wt. Loss mg	Percent Total Loss
31	97.0	500 ml. UDMH/N_2H_4	0.2	500 ml. UDMH/N_2H_4	0.0	800 ml. MMH	0.1	—	—	—	—	0.3
32	96.2	500 ml. UDMH/N_2H_4	0.1	500 ml. UDMH/N_2H_4	0.0	800 ml. MMH	0.2	—	—	—	—	0.3
33	68.9	24-hr. Shake MMH	0.5	—	—	—	—	—	—	—	—	0.7
34	73.3	"	1.3	—	—	—	—	—	—	—	—	1.8
35	75.0	"	1.2	—	—	—	—	—	—	—	—	1.6
36	98.9	"	0.3	—	—	—	—	—	—	—	—	0.3
37	96.7	"	0.3	—	—	—	—	—	—	—	—	0.3
38	93.7	170-hr. Shake MMH	0.5	—	—	—	—	—	—	—	—	0.5
39	94.8		0.7	—	—	—	—	—	—	—	—	0.7
40	95.6	"	0.8	—	—	—	—	—	—	—	—	0.8
41	96.5	"	0.9	—	—	—	—	—	—	—	—	0.9
42	97.0	"	1.0	—	—	—	—	—	—	—	—	1.0
43	99.8	"	0.8	—	—	—	—	—	—	—	—	0.8
44	99.2	"	0.9	—	—	—	—	—	—	—	—	0.9
45	97.6	"	1.1	—	—	—	—	—	—	—	—	1.1

APPENDIX C

COMPATIBILITY OF PRODUCTION MEMBRANES

(PROPELLANT TEST & SOLVENT TEST)

COMPATIBILITY OF PRODUCTION MEMBRANES

Control Membrane No.	Initial Wt. in mgs.	Run #1 Prop. Test	Wt. Loss mg	Run #2 Prop. Test	Wt. Loss mg.	Run #3 Prop. Test	Wt. Loss mg.	Run #4 Prop. Test	Wt. Loss mg.	Run #5 Prop. Test	Wt. Loss mg.	Percent Total Loss
1	95.3	500 ml. MMH	0.1	500 ml. MMH	0.0	500 ml. MMH	0.0	500 ml. MMH	0.0	—	—	0.1
2	95.1	"	0.0	"	0.0	"	0.0	"	0.0	—	—	0.0
3	96.0	"	0.0	"	0.0	"	0.0	"	0.0	—	—	0.0
4	94.5	500 ml. UDMH/N_2H_4	0.1	500 ml. UDMH/N_2H_4	0.0	500 ml. UDMH/N_2H_4	0.0	500 ml. UDMH/N_2H_4	0.0	—	—	0.1
5	96.9	"	0.1	"	0.0	"	0.0	"	0.0	—	—	0.1
6	95.4	"	0.0	"	0.0	"	0.0	"	0.0	—	—	0.1
7	99.3	500 ml. RFNA	0.7	500 ml. RFNA	0.2	500 ml. RFNA	0.3	500 ml. RFNA	0.0	—	—	1.2
8	99.3	"	0.6	"	0.3	"	0.3	"	0.0	—	—	1.2
9	100.5	"	0.7	"	0.2	"	0.4	"	0.0	—	—	1.3
10	101.8	"	0.6	"	0.2	"	0.4	"	0.0	—	—	1.2
11	101.5	100 ml. CH_2Cl_2	0.4	100 ml. Pet.Ether	0.0	100 ml. CH_2Cl_2	0.2	100 ml. RFNA	0.3	100 ml. RFNA	0.0	0.9
12	100.7	"	0.4	"	0.1	"	0.1	"	0.3	"	0.1	1.0
13	99.5	"	0.3	"	0.1	"	0.1	"	0.3	"	0.1	0.9
14	98.8	"	0.3	"	0.1	"	0.2	"	0.3	"	0.1	1.0
15	96.8	70-hr. Shake RFNA	0.6	4-hr. Shake RFNA	0.1	—	—	—	—	—	—	0.7
16	97.0	"	0.6	"	0.1	—	—	—	—	—	—	0.7
17	77.5	"	0.4	"	0.1	—	—	—	—	—	—	0.5

COMPATIBILITY OF PRODUCTION MEMBRANES (Cont'd)

Control Membrane No.	Initial Wt. in mgs.	Run #1 Prop. Test	Wt. Loss mg.	Run #2 Prop. Test	Wt. Loss mg.	Run #3 Prop. Test	Wt. Loss mg.	Run #4 Prop. Test	Wt. Loss mg.	Run #5 Prop. Test	Wt. Loss mg	Percent Total Loss
18	103.4	28-hr. Shake N_2O_4-.08% H_2O	0.1	—	—	—	—	—	—	—	—	0.1
19	103.3	"	0.2	—	—	—	—	—	—	—	—	0.2
20	103.7	28-hr. Shake N_2O_4- .21% H_2O	0.1	—	—	—	—	—	—	—	—	0.1
21	100.5	"	0.1	--	—	—	—	—	—	—	—	0.1
22	104.6	28-hr. N_2O_4- .36% H_2O	0.1	--	—	—	—	—	—	—	—	0.1
23	103.5	"	0.2	—	—	—	—	—	—	—	—	0.2
24	101.2	180-hr. N_2O_4- .26% H_2O	0.2	--	—	—	—	—	—	—	—	0.2
25	103.8	"	0.2	--	—	—	—	—	—	—	—	0.2
		Run #1 Solvent Test		Run #2 Solvent Test		Run #3 Solvent Test		Run #4 Solvent Test		Run #5 Solvent Test		
1	102.1	24-hr. CH_2Cl_2	0.5	60-hr. RFNA	0.6	4-hr. RFNA	0.0	—	—	—	—	1.1
2	103.1	"	0.5	"	0.6	"	0.0	—	—	—	—	1.1
3	101.7	"	0.7	"	0.5	"	0.0	—	—	—	—	1.2
4	102.1	"	0.5	"	0.6	"	0.0	—	—	—	—	1.1
5	104.3	"	0.6	"	0.6	"	0.0	—	—	—	—	1.2

COMPATIBILITY OF PRODUCTION MEMBRANES (Cont'd)

Control Membrane No.	Initial Wt. in mgs.	Run #1 Solvent Test	Wt. Loss mg.	Run #2 Solvent Test	Wt. Loss mg.	Run #3 Solvent Test	Wt. Loss mg.	Run #4 Solvent Test	Wt. Loss mg.	Run #5 Solvent Test	Wt. Loss mg.	Percent Total Loss
6	100.1	100 ml. CH_2Cl_2	0.3	100 ml. $CH_3CHOHCH_3$	0.0	100 ml. Pet.Ether	0.0	100 ml. CH_2Cl_2	0.1	100 ml. CH_2Cl_2	0.0	0.4
7	101.5	"	0.4	"	0.0	"	0.0	"	0.1	"	0.1	0.6
8	100.7	"	0.4	"	0.0	"	0.1	"	0.1	"	0.0	0.6
9	99.5	"	0.3	"	0.0	"	0.1	"	0.1	"	0.0	0.5
10	98.8	"	0.3	"	0.0	"	0.1	"	0.3	"	0.0	0.6
11	98.0	6-hr. Shaker Pet.Ether	0.5	—	—	—	—	—	—	—	—	0.5
12	98.2	"	0.6	—	—	—	—	—	—	—	—	0.6
13	99.7	16-hr. CH_3COCH_3	0.3	—	—	—	—	—	—	—	—	0.3
14	100.7	"	0.3	—	—	—	—	—	—	—	—	0.3
15	101.4	16-hr $CHCl_3$	0.9	—	—	—	—	—	—	—	—	0.9
16	101.3	"	0.9	—	—	—	—	—	—	—	—	0.9
17	100.1	16-hr. CCl_4	0.9	—	—	—	—	—	—	—	—	0.9
18	99.8	"	1.0	—	—	—	—	—	—	—	—	1.0
19	99.1	16-hr. $CH_3CHOHCH_3$	0.1	—	—	—	—	—	—	—	—	0.1
20	98.9	"	0.1	—	—	—	—	—	—	—	—	0.1
21	97.5	16-hr. CH_3CH_2OH	0.1	—	—	—	—	—	—	—	—	0.1
22	95.4	"	0.2	—	—	—	—	—	—	—	—	0.2

COMPATIBILITY OF PRODUCTION MEMBRANES (Cont'd)

Control Membrane No.	Initial Wt. in mgs.	Run #1 Solvent Test	Wt. Loss mg.	Run #2 Solvent Test	Wt. Loss mg.	Run #3 Solvent Test	Wt. Loss mg.	Run #4 Solvent Test	Wt. Loss mg.	Run #5 Solvent Test	Wt. Loss mg.	Percent Total Loss
23	102.1	24-hr. Shake CH_2Cl_2	0.5	70-hr. Shake RFNA	0.6	4-hr. Shake RFNA	0.0	—	—	—	—	1.1
24	103.1	"	0.5	"	0.6	"	0.1	—	—	—	—	1.1
25	101.7	"	0.7	"	0.6	"	0.0	—	—	—	—	1.3
26	102.1	"	0.5	"	0.6	"	0.0	—	—	—	—	1.2
27	104.3	"	0.6	"	0.6	"	0.0	—	—	—	—	1.2

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